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Planisphere, report that in accordance with the application of the said Henry Whitall, dated November 13 and approved November 20, 1882, they have examined the merits of the said Celestial Planisphere as requested. Two of the Planispheres were furnished to your Committee, accompanied by a full and detailed description thereof, which they find satisfactory, and to which they refer for information as to its construction and purposes. Ample evidence has been laid before your Committee, of the successful use of the simple Planisphere in Schools, Academies and Colleges, as well as by practical observers in the United States Naval Observatory and elsewhere. This addition to the original invention, for showing the changes in the position of the Pole Star and in the Right Ascension and Declination of other Stars, is simple and ingenious, and can be so explained as to be readily understood by ordinary students of Astronomy. Your Committee have been specially impressed with the completeness, simplicity, convenience, neatness and cheapness of the Planisphere, as well as with its fitness for the uses for which it is invented. They are of the opinion that it places Mr. Whitall "among ingenious men and women who make useful inventions," and they therefore recommend that he be awarded the Scott Legacy Premium, $20 and medal. Approved February 7, 1883. H. R. HEYL, Chairman Committee of Science and Arts. SEAL *. . . Attest: WM. H. WAHL, Secretary.*

GENERAL STATEMENT.—The *Equinoxes* move by precession from East to West (contrary to the hands of a watch on the Planisphere), about 14.4° per 1000 years—making a complete revolution around the Ecliptic in about 25,000 years. The *Apsides* move from West to East 2.2° upon an average per 1000 years, making a complete revolution in about 168,000 years. The Winter Solstice, which was in Aphelion in the Northern Hemisphere 11,700 years ago, meets Aphelion once in 21660 years, and 48° short of a complete revolution. This is the average for very long periods—sometimes varying greatly, however, owing to the varying motion of the Apsides, which sometimes move for hundreds of years much faster than above stated, at other times much slower, and sometimes have a retrograde motion. The average for the last 10,000 years was about the general average as above. It is now moving a little faster.

DESCRIPTION AND EXPLANATION OF THE PLANISPHERE.—The Starry Disk represents so much of the Heavenly Vault as is visible from latitude 40° North, being the whole of the Northern Hemisphere, and down to latitude 50° South. The Ecliptic and present line of the Equinoctial are drawn upon it, and the present line of the First Point of Aries. The metal circle represents the constant Equinoctial, and revolves around the Pole of the Ecliptic as its axis. The bar crossing and sustaining it represents the Solsticial Colure. The arm pivoted with this, and revolving around it, represents the motion of the Aphelion. The present place of the Winter Solstice Colure is with the end marked *Summer Solstice* at 90° Longitude from the First Point of Aries (or Right Ascension, also designated by two small star-like crosses inside the Ecliptic), and the end is moving toward the Pole. The present place of the Aphelion is at 278½° Longitude, also designated by one such cross (+) *outside* the Ecliptic. These two crosses, one inside, crossing, looking from the end of the Solstice Colure bar toward the other, is the Vernal Equinox. The First Point of Aries is always a line drawn from the Celestial North Pole to the Vernal Equinox. The motion of the Equinoxes is nearly uniform. The spaced crosses (+) inside the Ecliptic, mark the intervals traversed each 1000 years. The figures on the Colure bar, 23½° from the pole of the Ecliptic toward the Winter Solstice, represents the Celestial North Pole, and shows its place among the stars at every stage of the Equinoctial revolution. The Equinoctial Colure is used to designate the four seasons in the Northern Hemisphere; Spring, light green; Summer, red; Autumn, brown; Winter, white. The black rings on the Ecliptic and white parts mark midsummer and midwinter, July 16th and January 16th. The seasons participate in the precessional movement. By reason of this precessional movement, Northern latitudes of the earth will be carried into the southern heavens during half of a revolution, 12,500 years, modifying phenomena hereafter noticed. A complete revolution will bring back present conditions.

TO OPERATION.—By revolving the Equinoctial the precessional movement of the Equinoxes along the Ecliptic is shown, and the consequent translation of terrestrial latitudes northward and southward, and practically the swaying of the planes of parallels of latitude produced by the motion of the heavenly vault, are manifested to the eye. These oscillations of the stars, except within the Polar Circles—amount to 47°, twice the inclination of the Celestial from the Ecliptic Poles. Hence (except as to places within the Polar Circles), in the course of an entire Precessional Equinoctial Revolution, all stars within a breadth or belt of 47°, on each side of the Ecliptic, across which the Oscillating Plane of the parallel of the *place of observation* sways, and of which the axis of the Ecliptic is the central line, will be twice brought to the zenith of that place, and all stars within 90° of that belt, to the right or left, will be brought above the horizon. At the Polar Circle this belt is 47° wide, extending to the pole of the Ecliptic. Approaching nearer the Terrestrial Pole, its breadth diminishes 1° on each side for every

the hands of a watch, represent the daily rotation path, beneath the starry vault, of places on the given latitude at those stages of the precessional revolution, and in the aggregate mark out the belt referred to. To ascertain when any star within that belt will come to the zenith, set dividers as before, and revolving the Equinoctial from its *present position* as a starting point, stop when the free point will reach the star selected. Then count the time in thousands of years by the crosses along the Ecliptic, from the starting point to the Summer Solstice arm of the Colure bar. At North latitude 40° (designated by a second file-mark on Colure bar), Algol will be found in the zenith 200 years hence; Vega, 2,300; Alpha Andromeda, 3,200; Capella, 3,400; Altair, 8,000; and Polaris within 3° of zenith, 12,700 years hence. At the last-mentioned time a zenith will also be reached 7° south of the present Equinoctial, culminating 12 hours after Polaris in the Earth's diurnal revolutions; and the dweller at this latitude will then enjoy the same view of the Southern Heavens as is now had from a standpoint 7° south of the equator. Every prominent star in or near the path of the Celestial North Pole will, in this precessional revolution, in turn become the Pole star: 2,800 years hence it will be Gamma in Cepheus; 6,500 years hence, Alpha in the same constellation; in 11,800 years, Vega; 19,800 years hence it will be Alpha Draconis, as it also was 5,200 years ago. Each will be the Pole-star for several centuries. The position assigned to stars after very long periods, however, will in some cases be sensibly modified by their proper motions. To find when any star will become the Pole star, bring the Celestial North Pole to the star, and count the time on the Ecliptic as before.

MOTIONS OF THE STARS IN RIGHT ASCENSION AND DECLINATION ILLUSTRATED.—The stars, as shown in Star Catalogues, are constantly gaining in Right Ascension, that is, in distance east of the Vernal Equinox. They have an apparent movement of 1° in about 70 years, except as affected by their own proper motions. This apparent motion is caused by the real motion of the Vernal Equinox west by precession. For illustration, bring the Aphelion arm to rest at the Vernal Equinox, to represent the constant First Meridian (not quite correct, however, as the central end, and axis of rotation, should be at *Celestial* North Pole), and the gain is seen as the stars pass under it and around during the precessional movement. The change in Declination also, as noted in Star Catalogues—some stars moving northward and others southward—is at the same time illustrated. Remembering that gain in Northern Declination is an approach to the Celestial North Pole, and gain in Southern Declination is departure therefrom or approach to the Celestial South Pole, revolve the Equinoctial, and see stars coming into its circle and so approaching its centre (the Celestial North Pole), all round from the Summer Solstice, via the Vernal Equinox, to the Winter Solstice, and passing out or retreating on the other side of the Solsticial Colure. This Colure divides the stars of the firmament into two hosts, one moving north and the other south. Their direction is reversed every half revolution of the Equinoctial. The vibration amounts to 47°, and proceeds at the varying rate of from 1° in about 166 years at the Equinoctial Colure, where it is most rapid, to zero at the Solsticial Colure. It is only *apparent*, however, and due to the real motion of the Pole in the precessional revolution.

SECULAR CHANGES OF CLIMATE.—Changes of temperature, occupying long periods, and alternating between the Northern and Southern Hemispheres, are produced by the combined operation of the precessional movement and that of the Apsides, and are dependent for their extent upon the eccentricity of the Earth's orbit. This eccentricity varies between extreme limits of .078 and .003 of the orbit's radius. The Earth's Aphelion distance in one case exceeds its perihelion distance by over 14,000,000 miles; in the other by little more than one-fourth of a million. In whichever Hemisphere midwinter meets Aphelion there is, according to the popular theory of Mr. James Croll, a secular refrigeration, proportionate to the eccentricity at the time, by increase both in length and intensity of the winters; in the other Hemisphere, a proportionate shortening of winter

constructed by Leverrier's process, are for that last 40,000 years and subsequent time. The columns for excess of winter over the present in length and cold are carried out only to the end of the Glacial Epoch. The process, carried out in accordance with present eccentricity, finds Winter temperature of Southern Hemisphere, where Aphelion is near midwinter, to be 18° Fahr. colder than of Northern under similar exposures—which agrees well with the fact.

No. of years before A. D. 1800.	Eccentricity of Earth's Orbit.	Longitude of Aphelion.	No. of Degrees passed over by Aphelion. Motion Retrograde when marked R.	Winter occuring in Aphelion.	
				Excess of Winter over Summer, in days.	No. of degrees by which mid-winter temperature is lowered in middle latitudes.
120,000	0.0431	274 47	° ′		°
110,000	0 0461	293 48	19 01	21.4	32.4
102,000—100,000	0.0473	316.18	22 30	22.	33.
91,000	0.0452	340.02	23.44	21.	32.
81,000— 80,000	0.0398	4.13	24.11	18.5	29.4
70,000	0.0316	27.22	23.09	14.7	25.5
59,000— 60,000	0.0218	46.08	18.46		
50,000	0.0131	50.14	4 06		
40,000	0.0109	28.36	21.38 R		
31,000— 30,000	0.0151	5 50	22.46 R		
20,000	0.0188	44.	38 10		
10,200— 10,000	0.0187	78 28	34.28		
1,800	0.0168	99.30	21.02	x7.7 *less*	x x

x Winter being then in *perihelion*.
x x Present mid-winter temperature of given latitude or locality.

APPLICATION OF PLANISPHERE.—Adjust the Equinoctial and Aphelion to their present positions on the disk, and move each in its proper direction, and at their present proportionate rates, till *midsummer* meets Aphelion. This is found to occur about 800 years hence, ~~A.D. 2680~~, up to which time Winter will grow milder and Summer cooler in the Northern Hemisphere, and the opposite in Southern Hemisphere. Thence onward the climates of the Hemispheres will begin to be reversed. Carry forward the movements at same comparative rates till *midwinter* meets Aphelion—about 11,630 years hence, or A. D. 13,500—and the reversal will be complete:—the climatal effects diminished, however, by a greatly diminished eccentricity of the orbit. To find when midwinter in Northern Hemisphere was in Aphelion back through the Glacial Epoch, the movements must be reversed, and Aphelion must be given the rate and direction of motion shown in the tables for each 10,000 years, instead of the present. Starting again from present positions and moving backwards, midwinter is found to have been in Aphelion (refrigeration culminating) at about the following dates before A. D. 1800, viz: 10,200, 31,000, 59,000, 81,000, and 102,000 years; the longitude of Aphelion being respectively 78°, 3°, 1°, and 310°. The last-mentioned date was at the time of greatest eccentricity of the tabulated part of the Epoch, and central of thousands of years of its greatest refrigeration spent upon the Northern Hemisphere, bringing ice cap and drift deposits far down over middle latitudes. It was preceded and followed by periods as long, during nearly equal eccentricity, in which, *summer* being in Aphelion, and glaciation shifted to the Southern Hemisphere, winter was almost unknown in the Northern, and forests and vegetation of temperate climates reached almost to the Pole. The cycle of these changes was from one meeting of midwinter with Aphelion to the next in the precessional revolutions. The glaciation of 81,000 years ago, which was the last, was much lighter and less extensive in its effects. An easy way of arriving at the time of such conjunctions is to give Aphelion about the movement indicated by the tables for the period (or at present rate if the rate is not known), and holding it to the place revolve the Equinoctial for the same period, and then adjust back or forward—giving each its proportion of movement—till the conjunction is reached, and then count the

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